



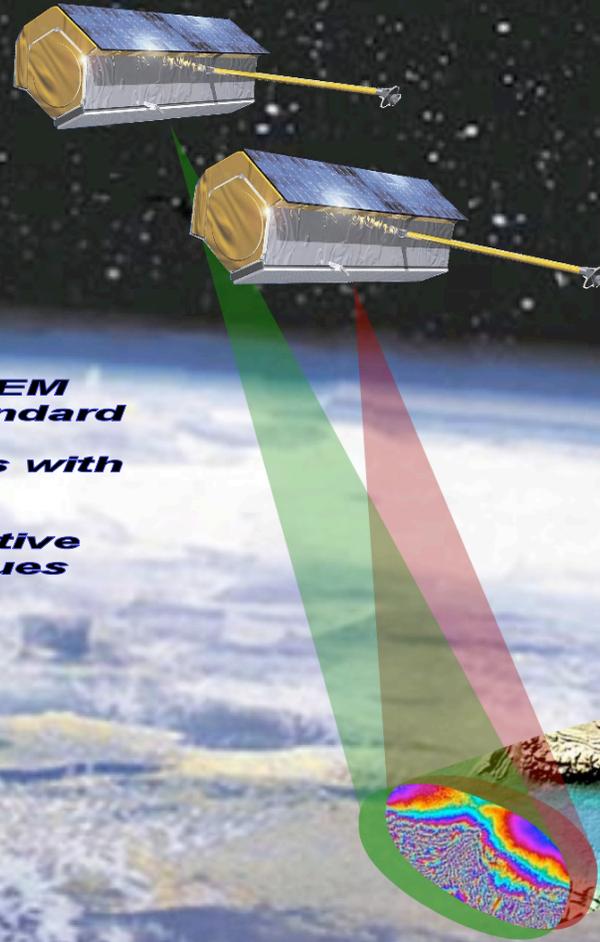
TanDEM-X: Mission Overview & Status

M. Zink, G. Krieger, H. Fiedler, A. Moreira, B. Döring

DLR - Microwaves and Radar Institute



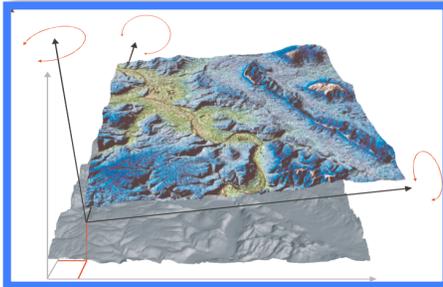
TanDEM-X Mission Goals



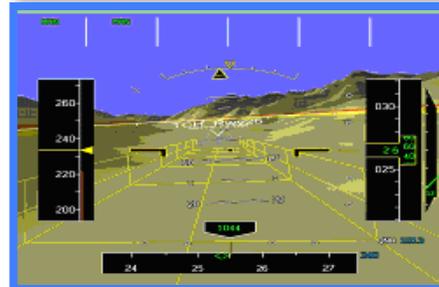
- **acquisition of a global DEM according to Level-3 standard**
- **generation of local DEMs with Level-4 like quality**
- **demonstration of innovative bistatic imaging techniques and applications**

TerraSAR add-on for Digital Elevation Measurements

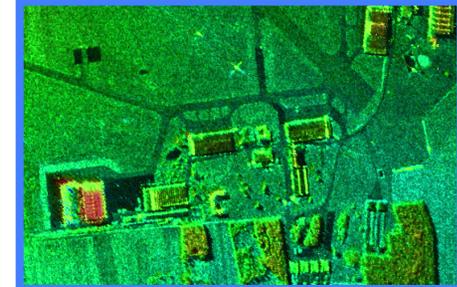
Applications of Cross-Track Interferometry



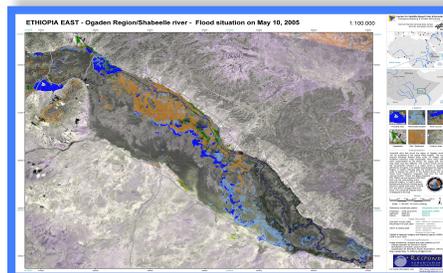
Topography



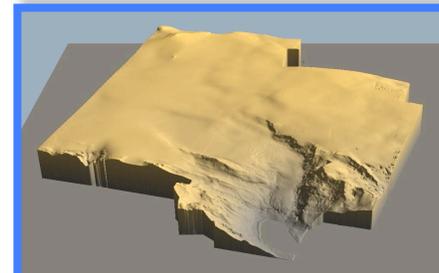
Navigation



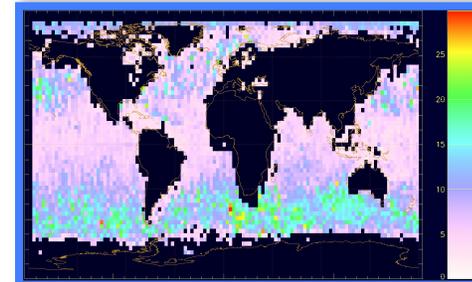
Urban Areas



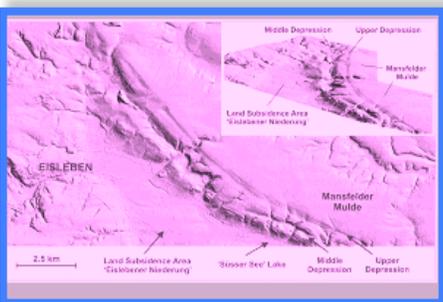
Crisis Management



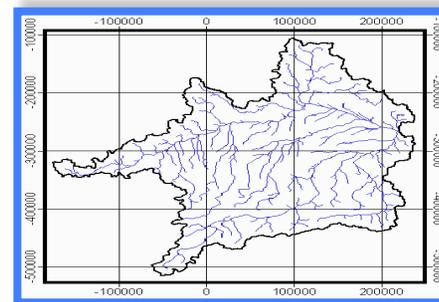
Glaciology



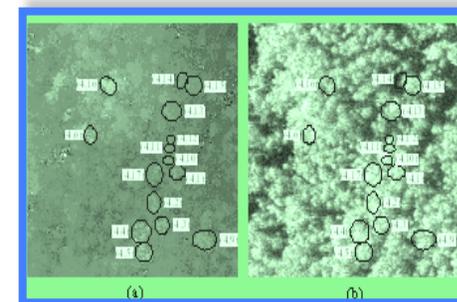
Oceanography



Geology
Deutsches Zentrum
für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft



Hydrology

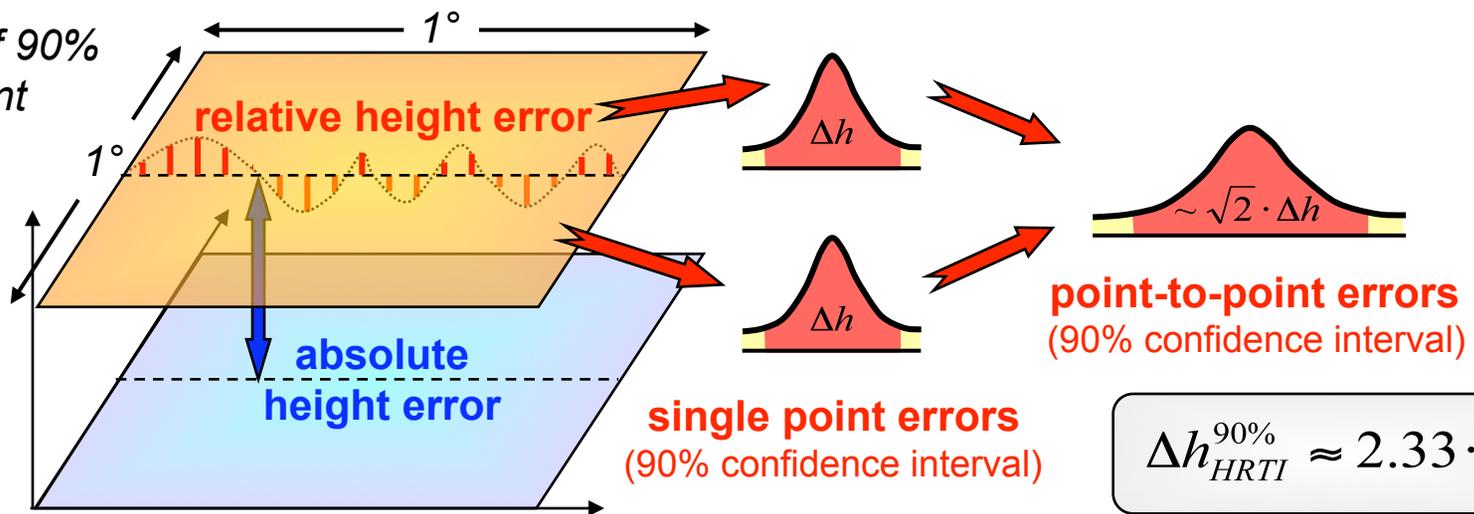


Land Use

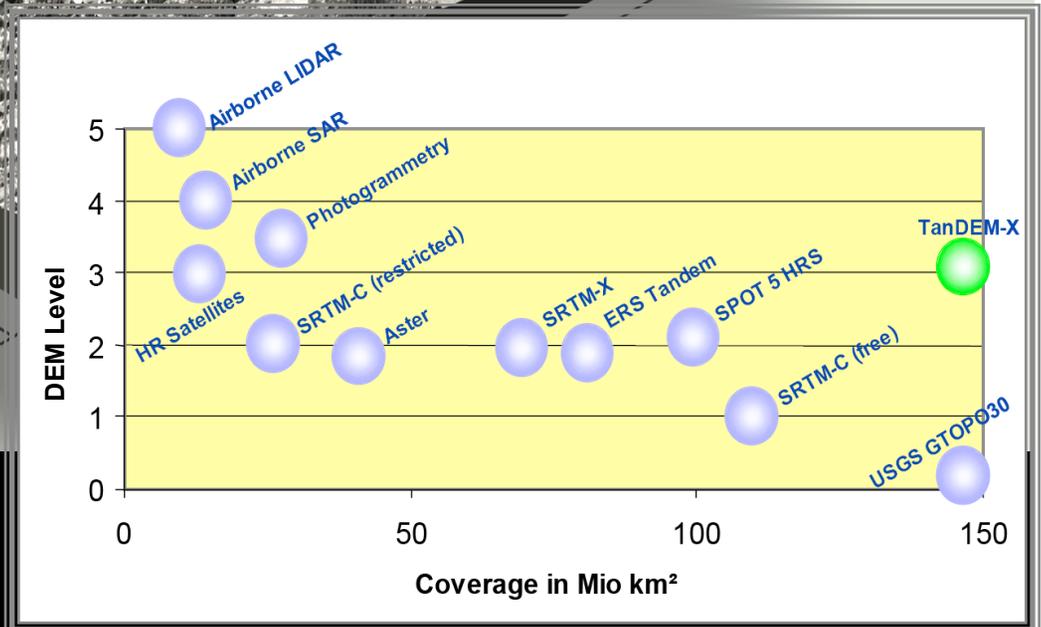
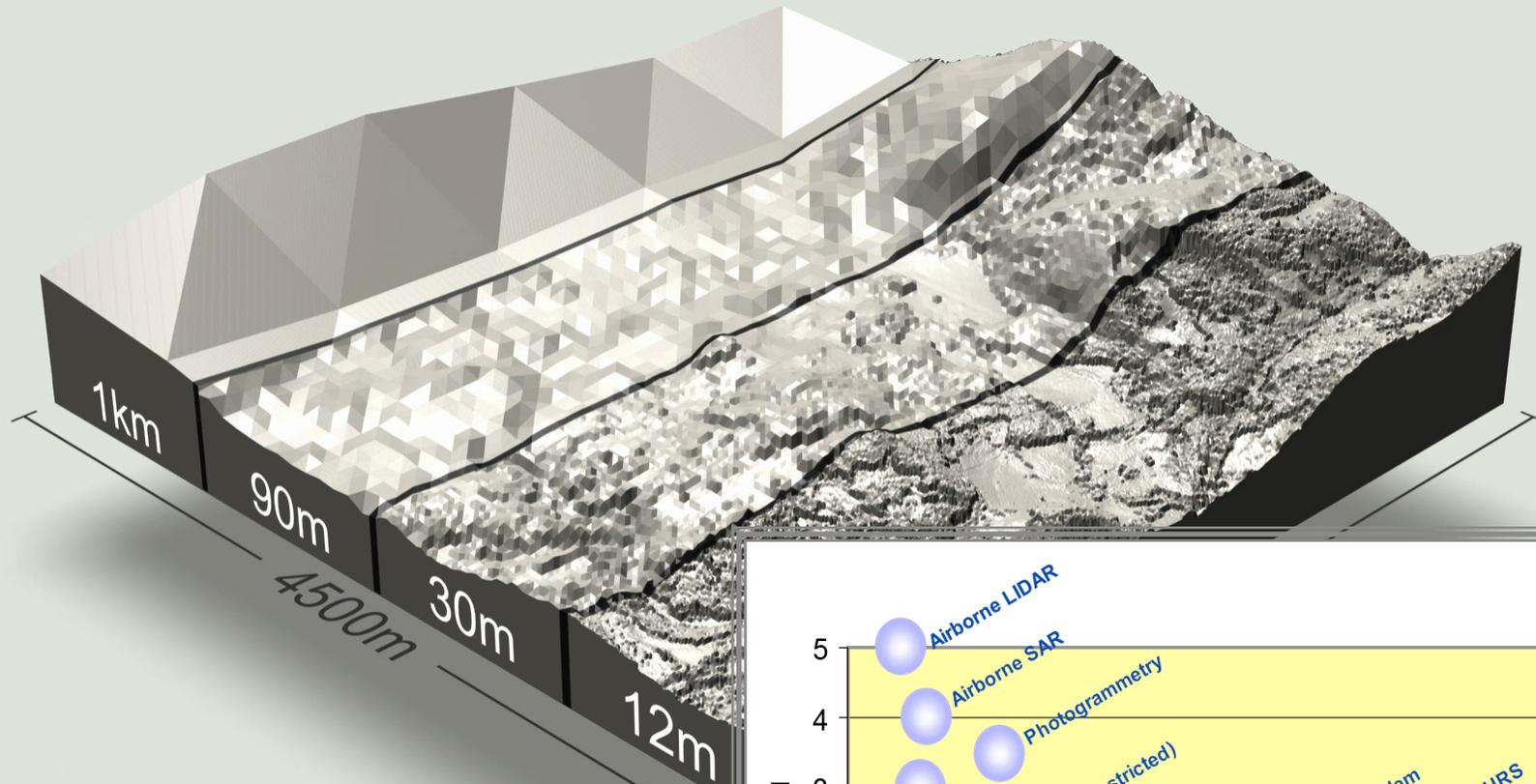
Standards for Digital Elevation Models

	Spatial Resolution	Absolute Vertical Accuracy (90%)	Relative Vertical Accuracy (point-to-point in 1° cell, 90%)
DTED-1	90 m x 90 m	< 30 m	< 20 m
DTED-2	30 m x 30 m	< 18 m	< 12 m
TanDEM-X	12 m x 12 m	< 10 m	< 2 m
Level-4	6 m x 6 m	< 5 m	< 0.8 m

Definition of 90% point-to-point errors:

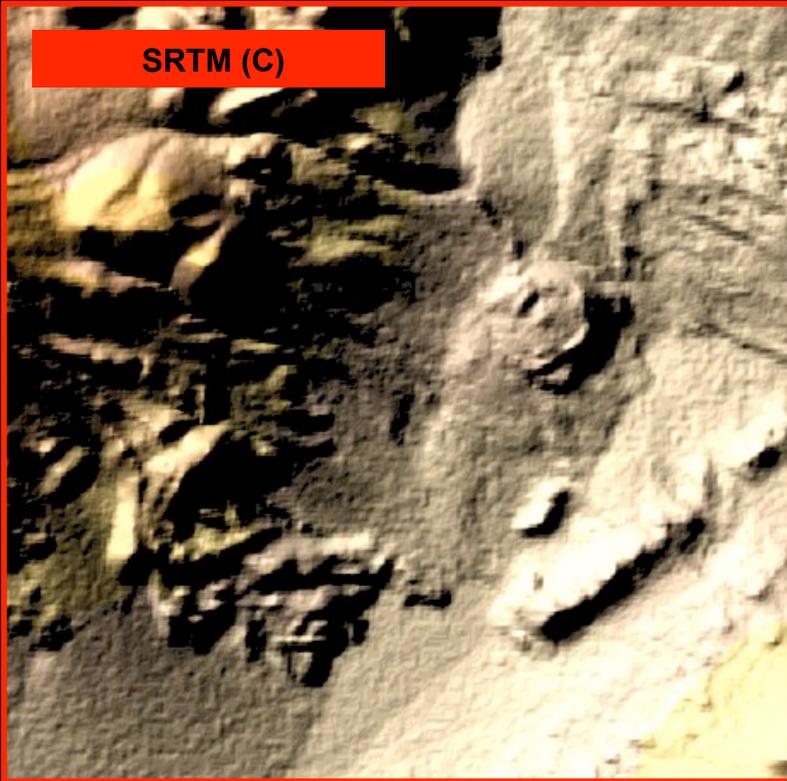


Comparison of DEM Resolutions

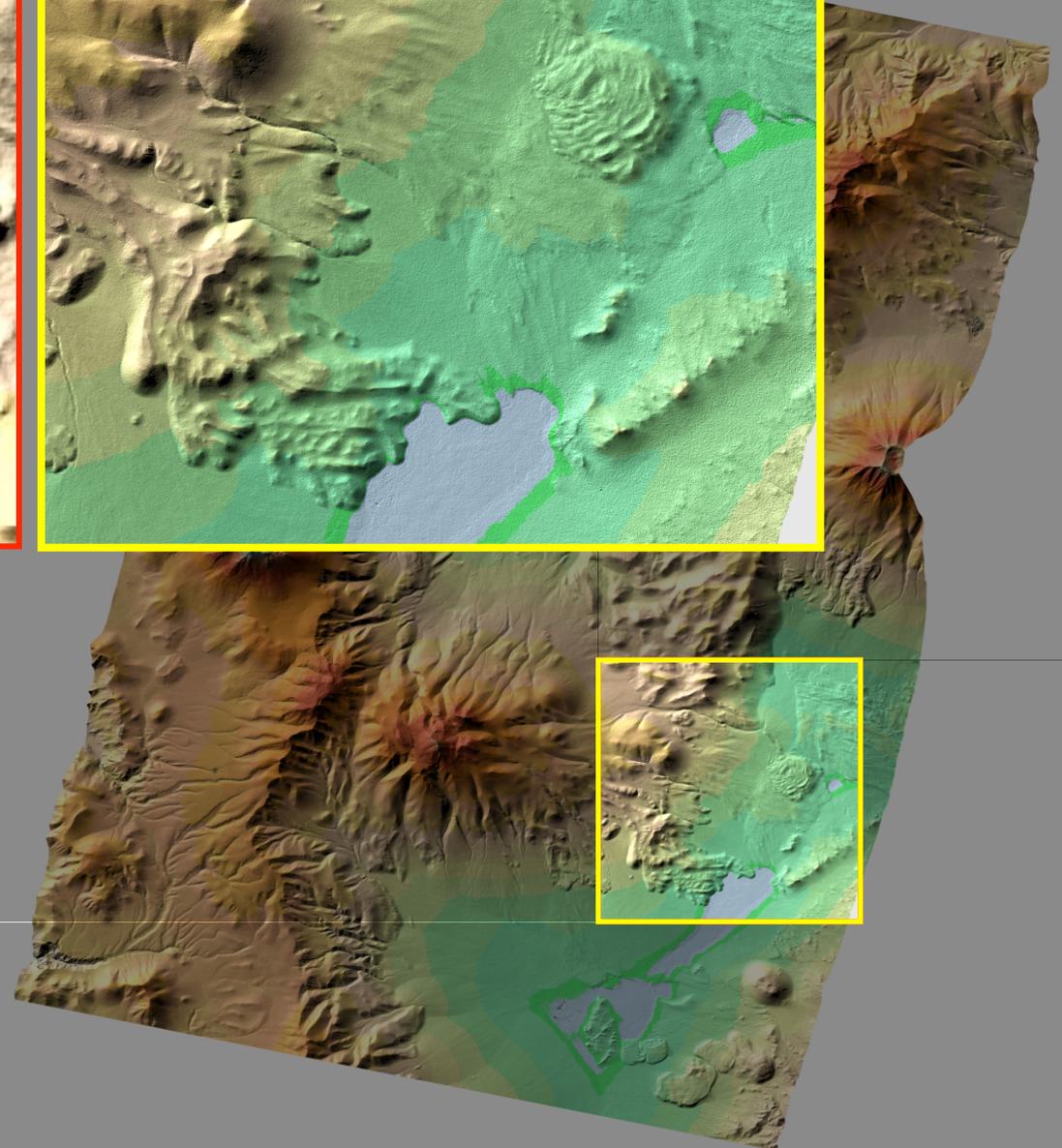
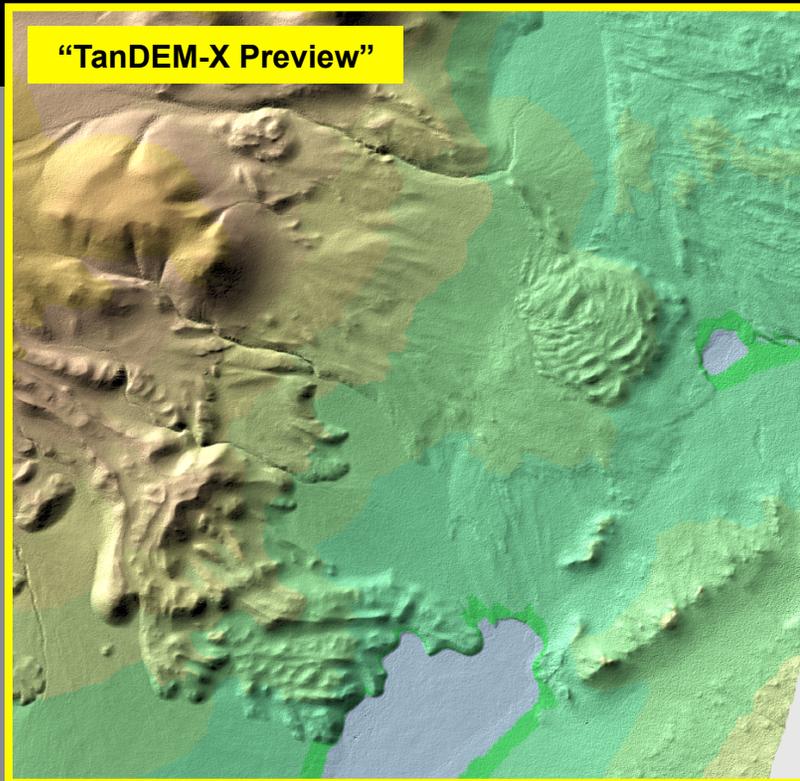


Expected TanDEM-X DEM Quality

SRTM (C)

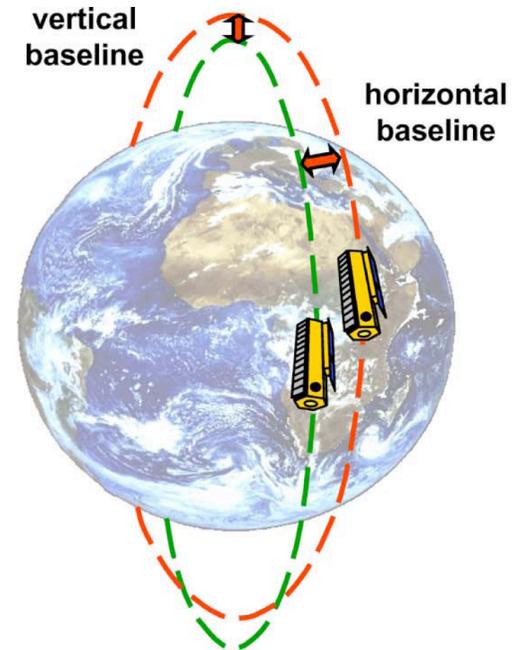
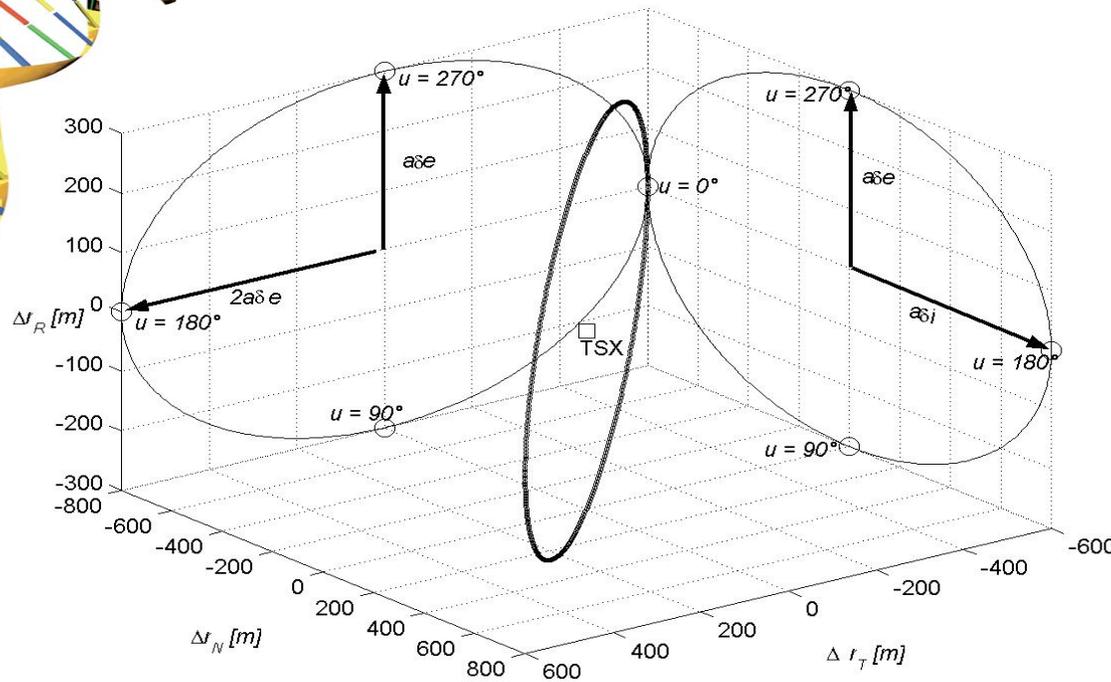
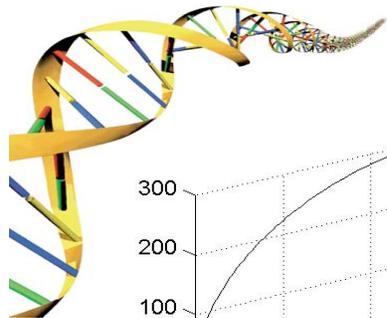


"TanDEM-X Preview"



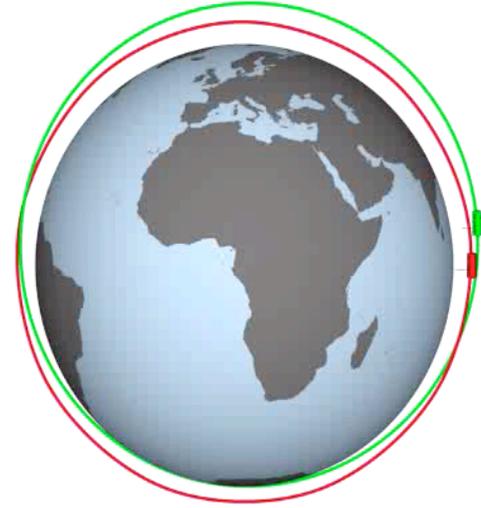
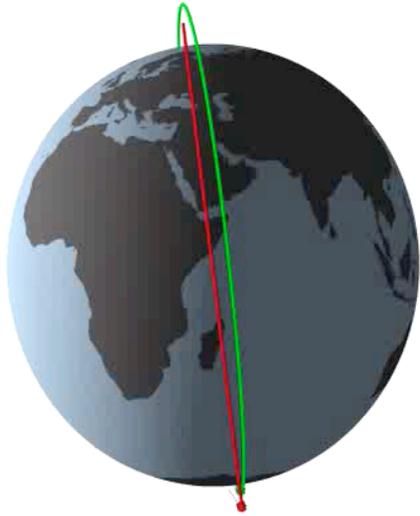


Collision Avoidance - HELIX Formation

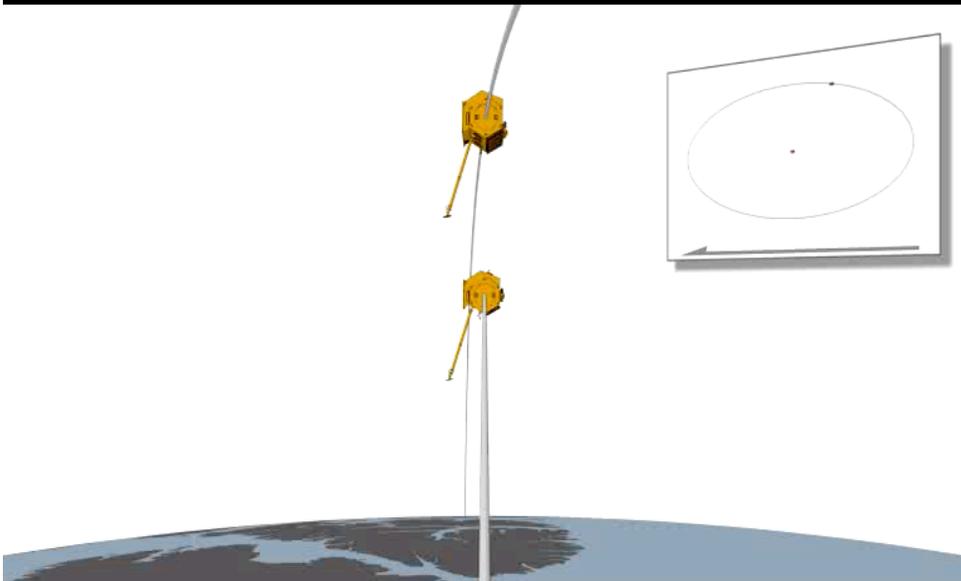


HELIX satellite formation enables safe operation

- ✗ *horizontal cross-track separation at equator by different ascending nodes*
- ✗ *vertical (radial) separation at poles by orbits with different eccentricity vectors*

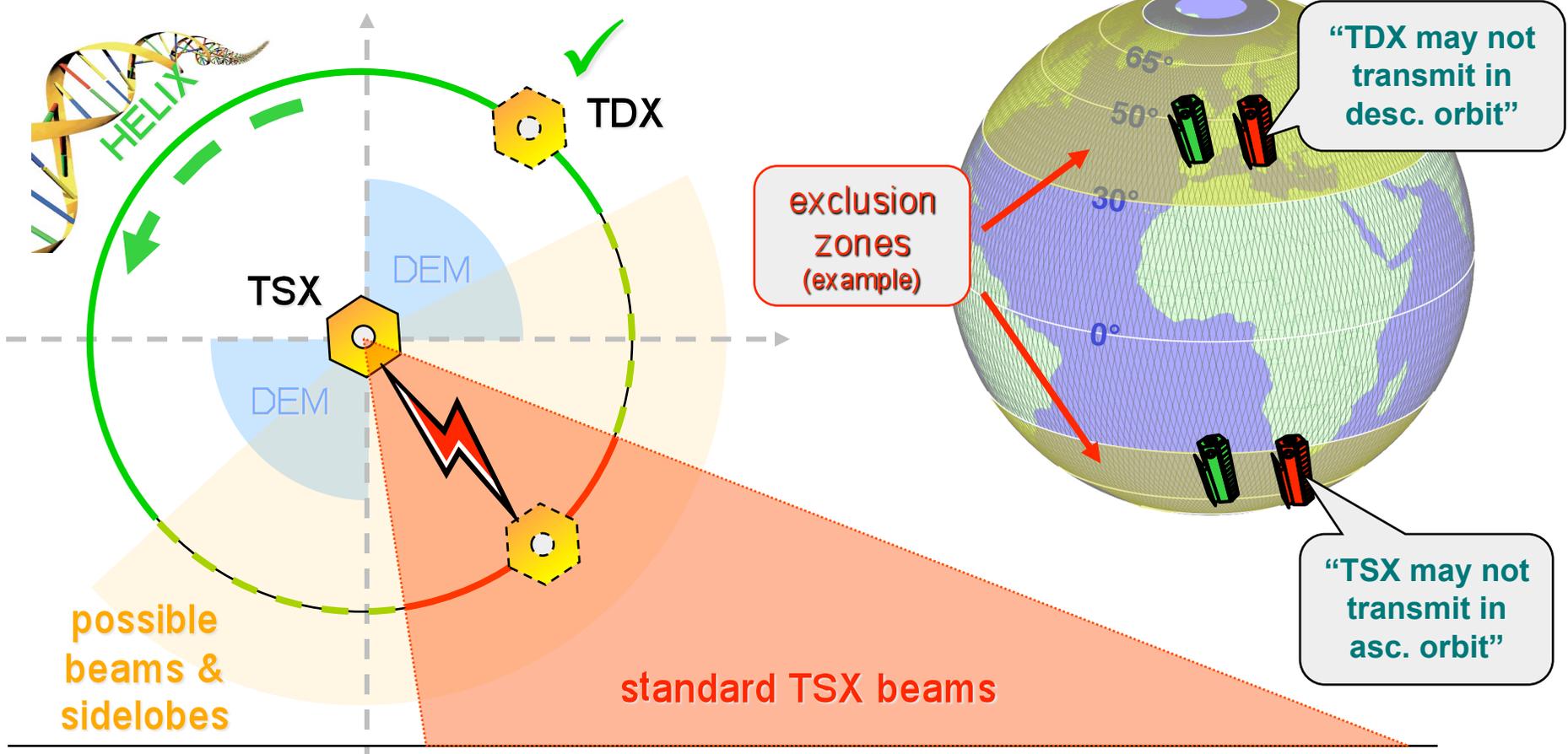


HELIX-Formation





Exclusion Zones



**Definition of exclusion zones for TSX & TDX based on beam table.
 Different exclusion zones in case of left-looking operation !**

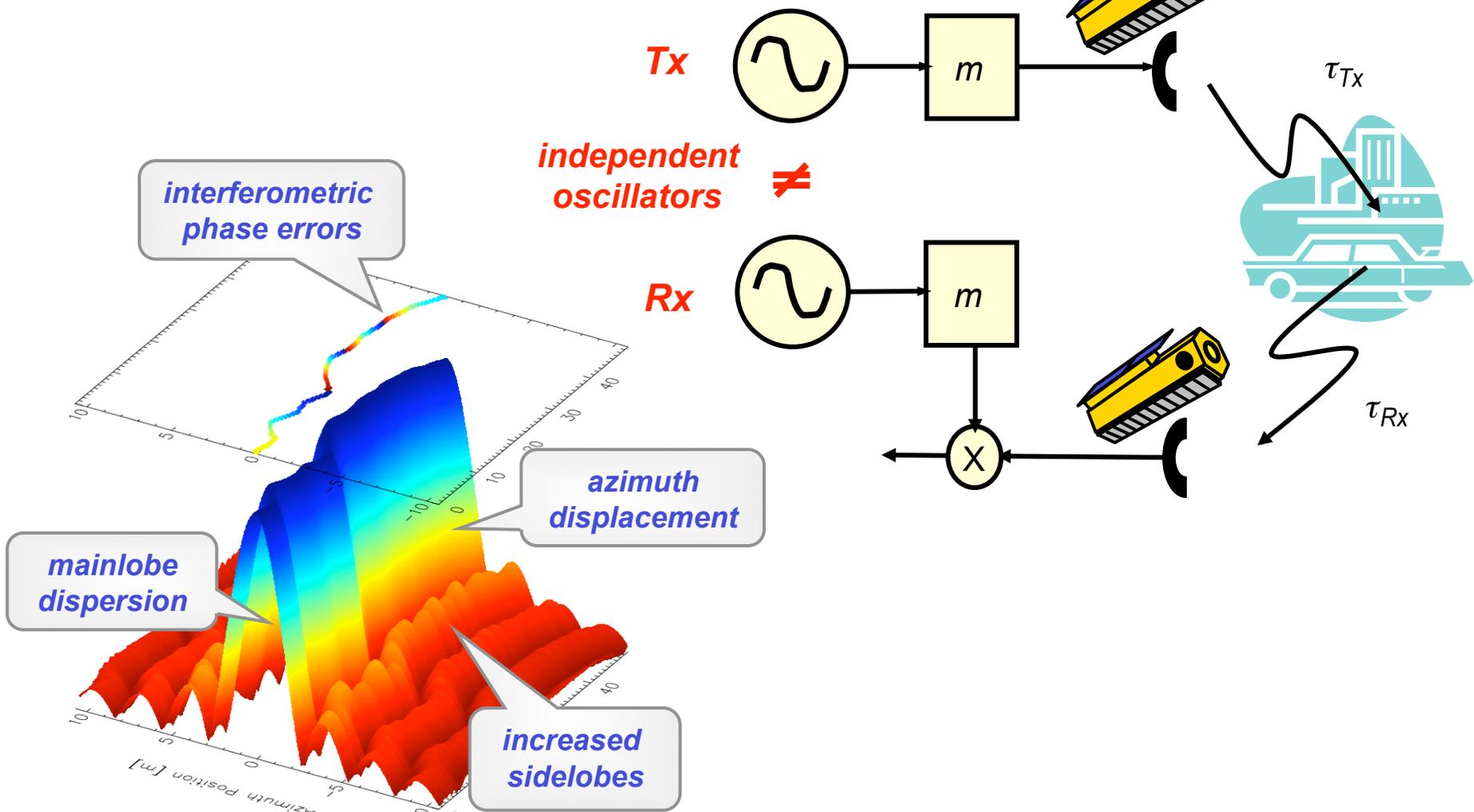


TanDEM-X Data Acquisition Modes

Pursuit Monostatic	Bistatic	Alternating Bistatic
<ul style="list-style-type: none"> ✗ both satellites transmit and receive independently ✗ temporal decorrelation & atmospheric disturbances ✗ backup solution 	<ul style="list-style-type: none"> ✗ one satellite transmits and both satellites receive simultaneously ✗ dual use of signal energy ✗ requires synchronisation 	<ul style="list-style-type: none"> ✗ transmitter alternates between PRF pulses ✗ provides two baselines ✗ enables synchronisation, calibration & verification



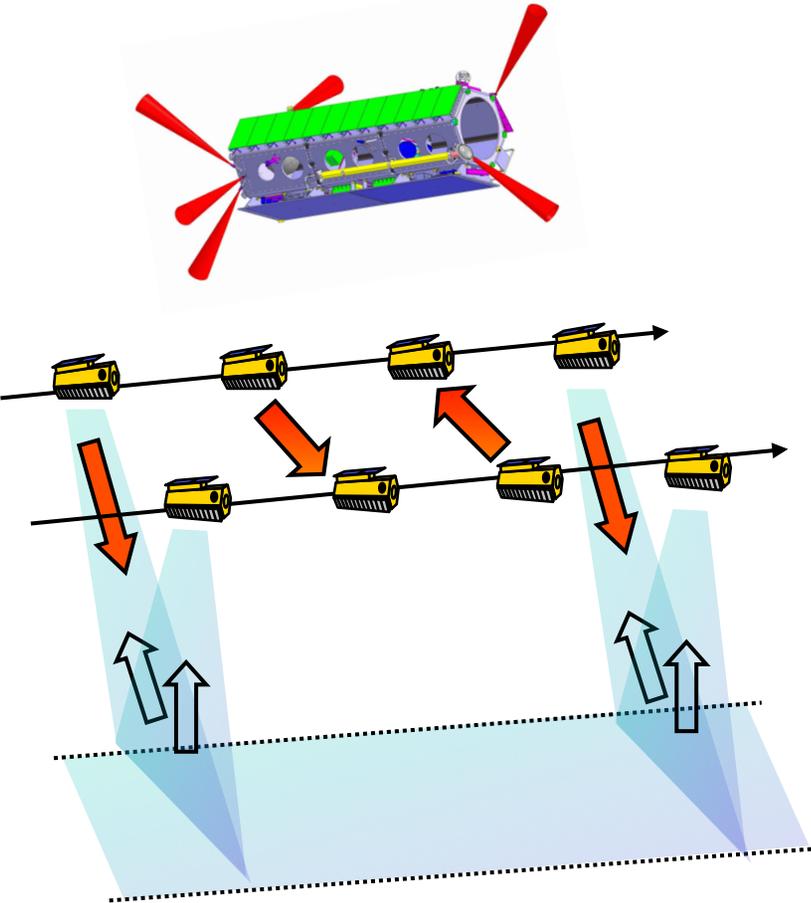
Impact of Oscillator Noise



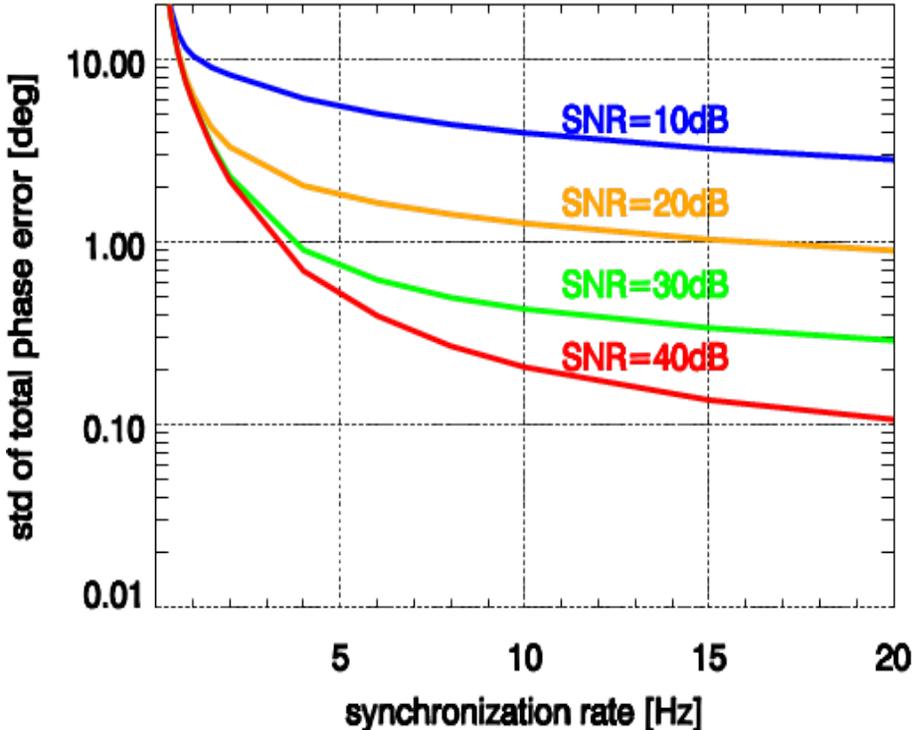


Phase Referencing in TanDEM-X

Synchronisation Link



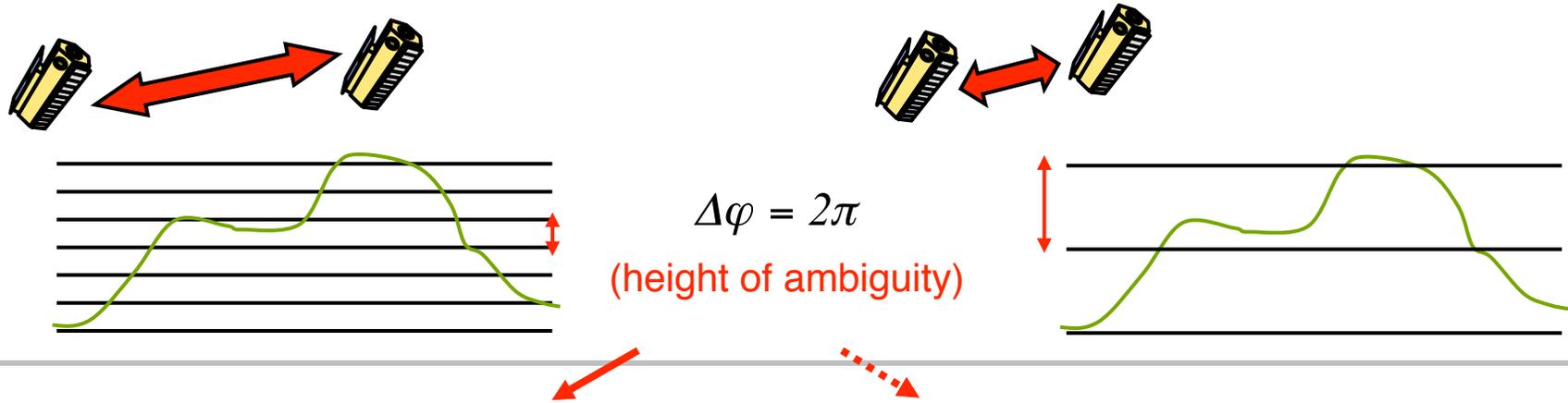
Analysis of Residual Errors



⇒ phase referencing can achieve short term rmse below 1°

Height of Ambiguity

TanDEM-X enables large baselines which allow for ultra high resolution DEMs with height accuracies in the sub-meter range, but ...

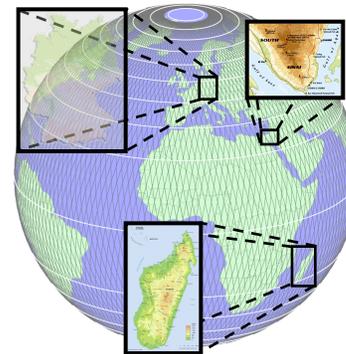


Compromise on Accuracy for Global DEM



- ✗ use reduced baselines
- ✗ additional acquisitions for difficult terrain
- acquisition scenario for global DEM according to HRTI-3

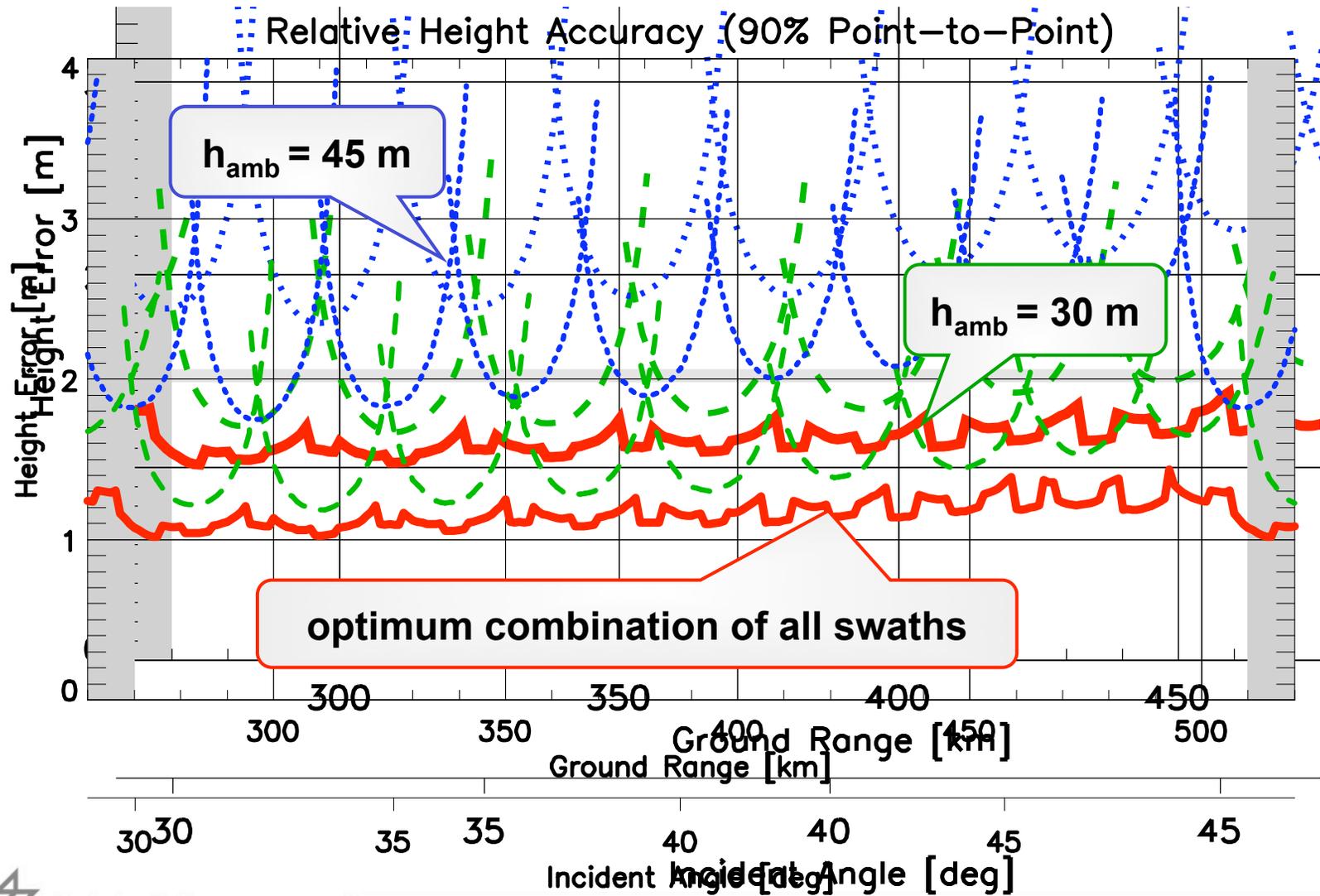
Local/Regional Ultra High Resolution DEMs



- ✗ multiple data acquisitions with large and small baselines
- regional DEMs with sub-meter resolution (e.g. HRTI-4)



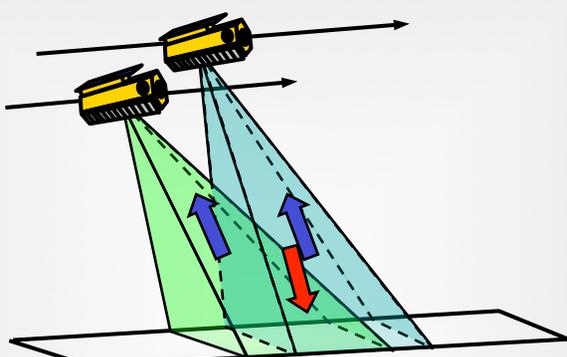
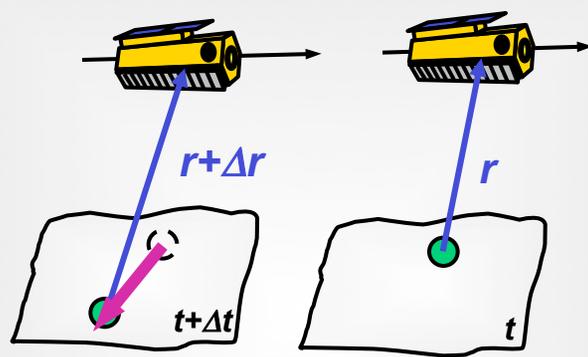
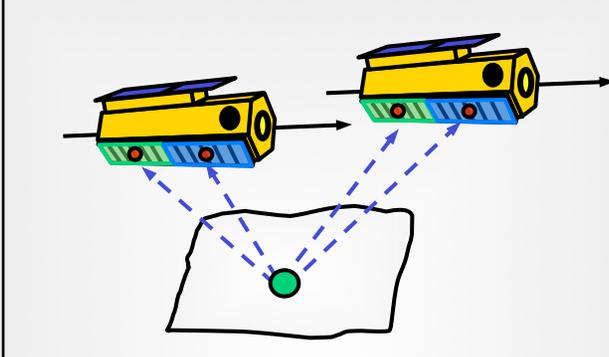
Combination of Interferometric DEM Acquisitions



Capabilities of TanDEM-X

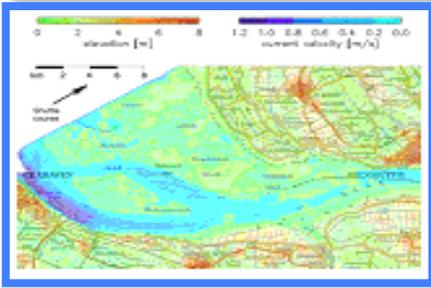
- cross-track baselines (0 km to several km)
- along-track baselines (0 km to several 100 km)
- interferometric modes (bistatic, alternating, monostatic)
- SAR modes (ScanSAR, Stripmap, ...)
- bandwidth / resolution (0 ... 150/300 MHz)
- incident angles (20° ... 55°)
- polarisations (single, dual, quad)
- ...

TanDEM-X is a highly flexible sensor which enables multiple powerful imaging modes

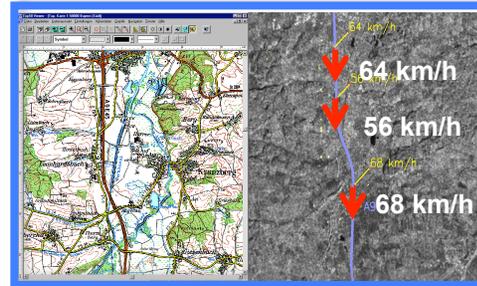
Cross-Track Interferometry	Along-Track Interferometry	New Techniques
		
<ul style="list-style-type: none"> → Digital Elevation Models → Spatial Coherence (forest, ...) → Double DInSAR (change maps, ..) → High Resolution SAR Images 	<ul style="list-style-type: none"> → Large Scale Velocity Fields (ocean currents, ice drift, ...) → Moving Object Detection → Temporal Coherence Maps 	<ul style="list-style-type: none"> → 4 Phase Center MTI (traffic, ...) → PolInSAR (vegetation height, ...) → Digital Beamforming (HRWS, ...) → Bistatic Imaging (classification, ..)

Applications ATI & New Techniques

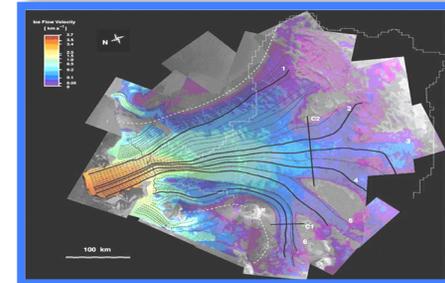
Along-Track Interferometry



Ocean Currents

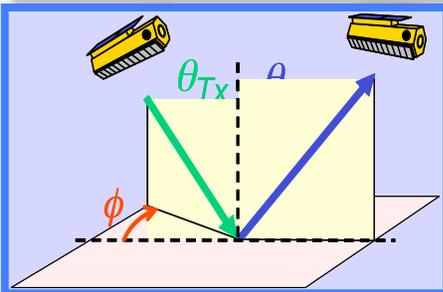


Traffic Monitoring

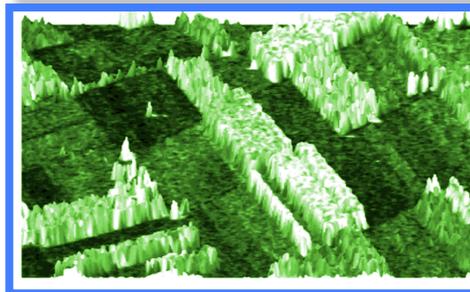


Glacier Mass Balance

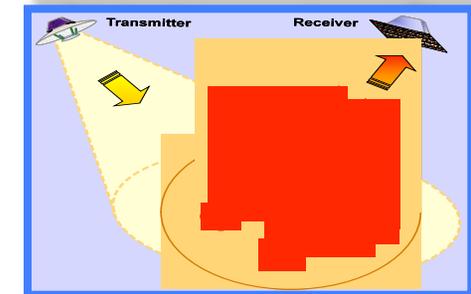
New SAR Techniques



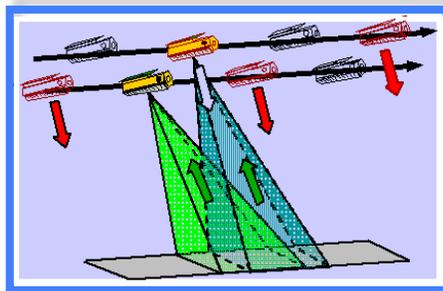
Bi-Static SAR



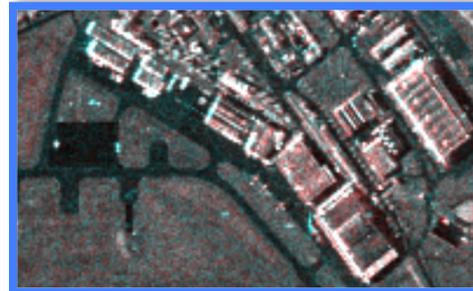
Polarimetric InSAR



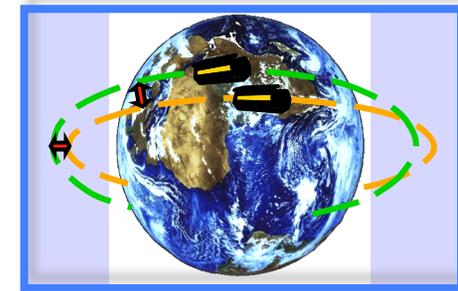
Digital Beamforming



InSAR Processing



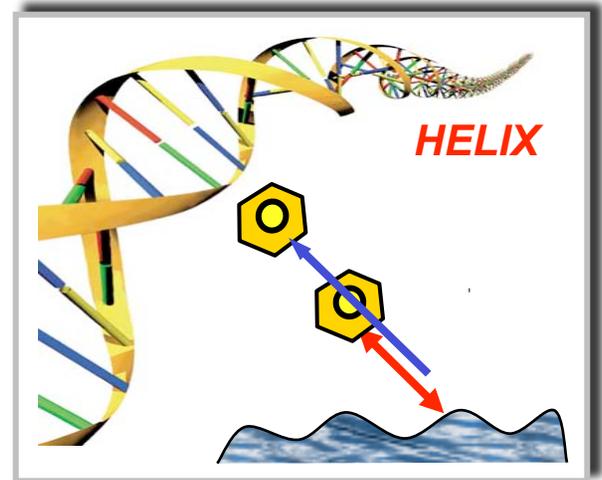
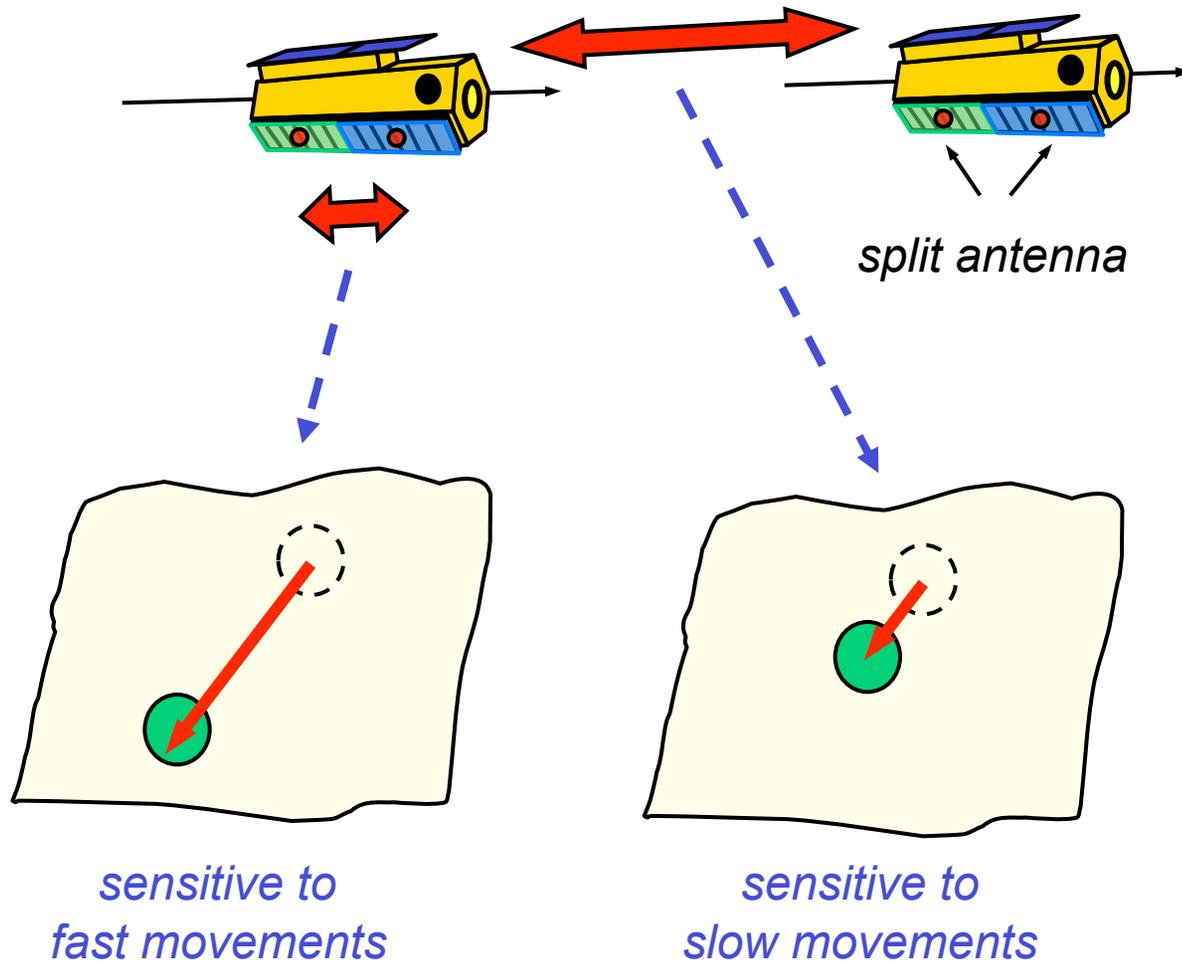
Super Resolution



Formation Flying



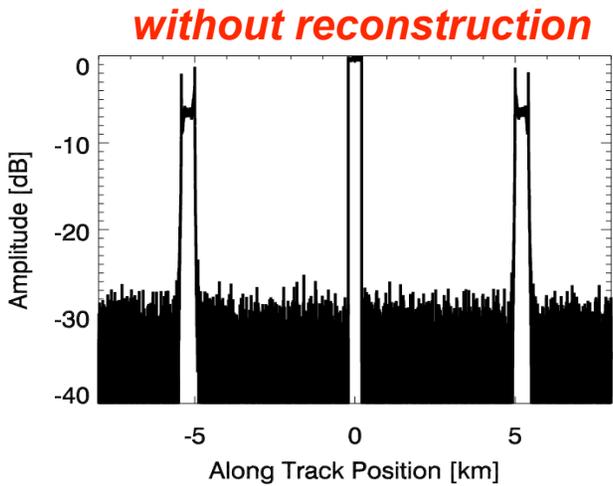
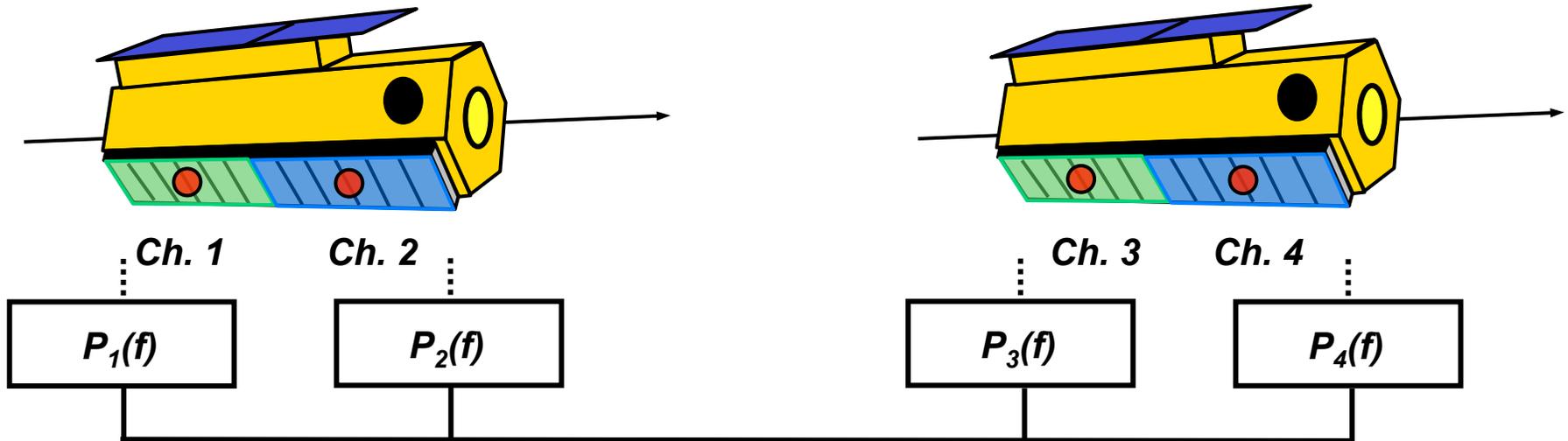
Along-Track Interferometry



B_{along}	2.4 m	100 m
Δx	12 m	12 m
σ^0	- 12 dBm ² /m ²	
θ_{inc}	45°	
v_{amb}	500 km/h	12 km/h
Δv	~9 km/h	0.2 km/h

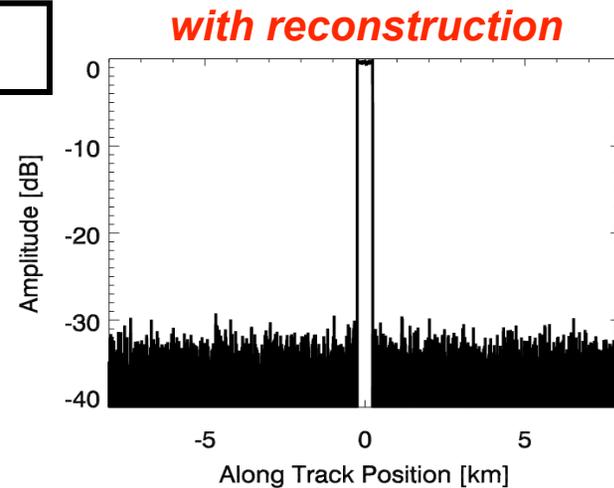


Digital Beamforming with Four Phase Centres



SAR Proc.

*Ambiguity
Suppression*

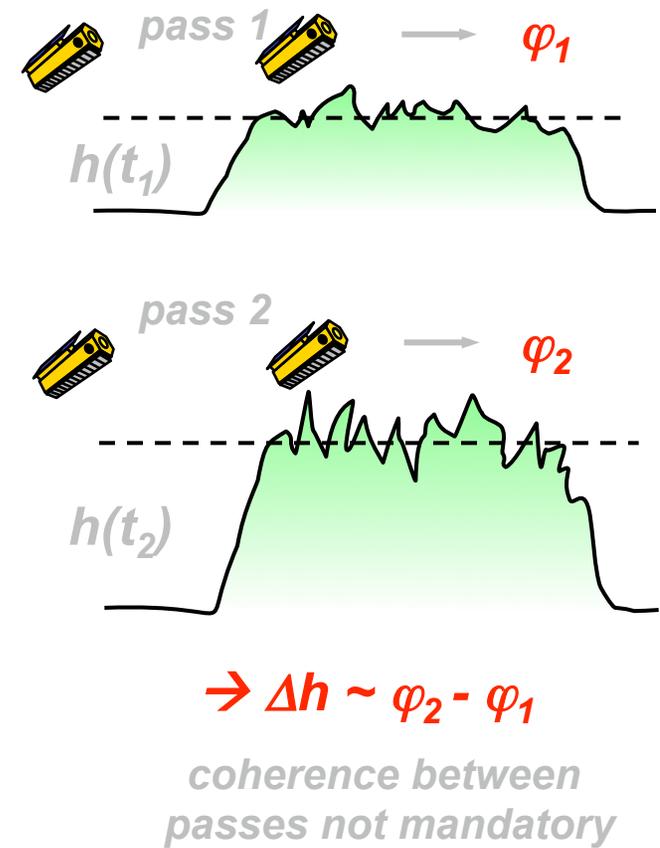
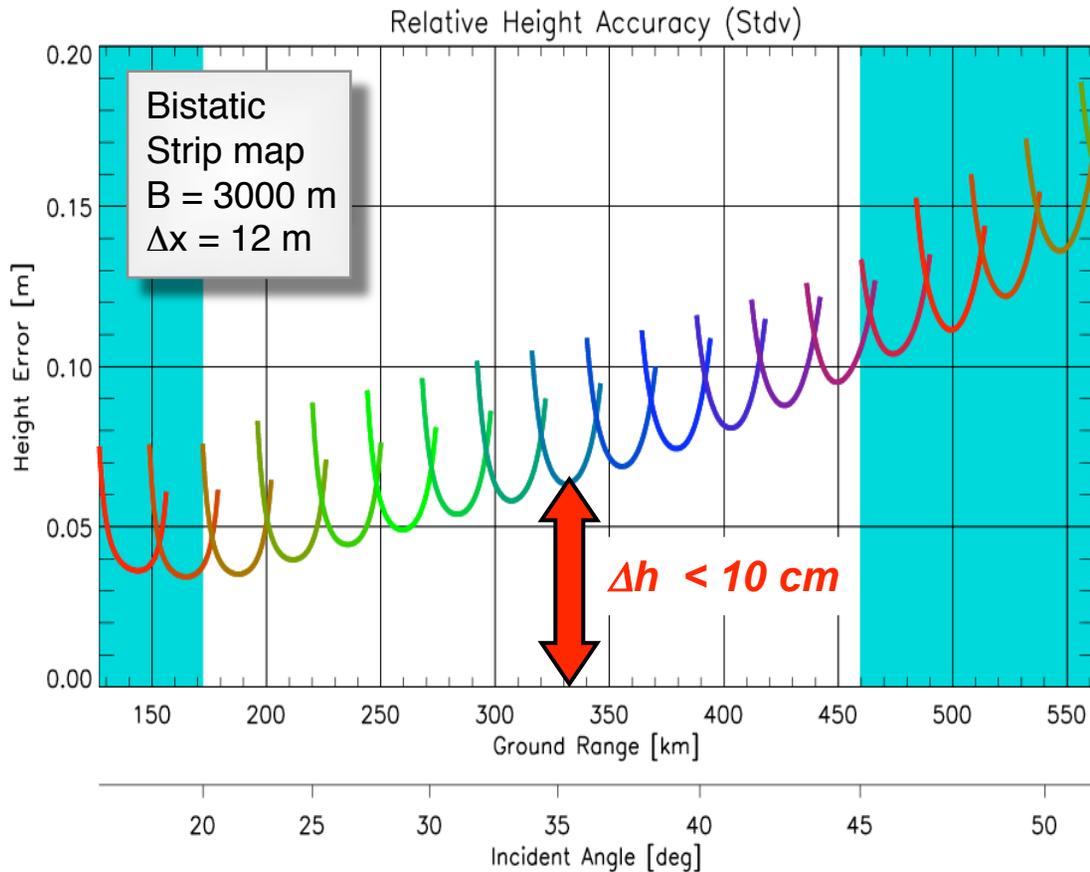


*Enables
High
Resolution
Wide
Swath
Imaging*



“Double Differential SAR Interferometry”

e.g. difference between two single-pass cross-track interferograms



→ Grounding line detection, vegetation growth, snow/ice accumulation, ... ?



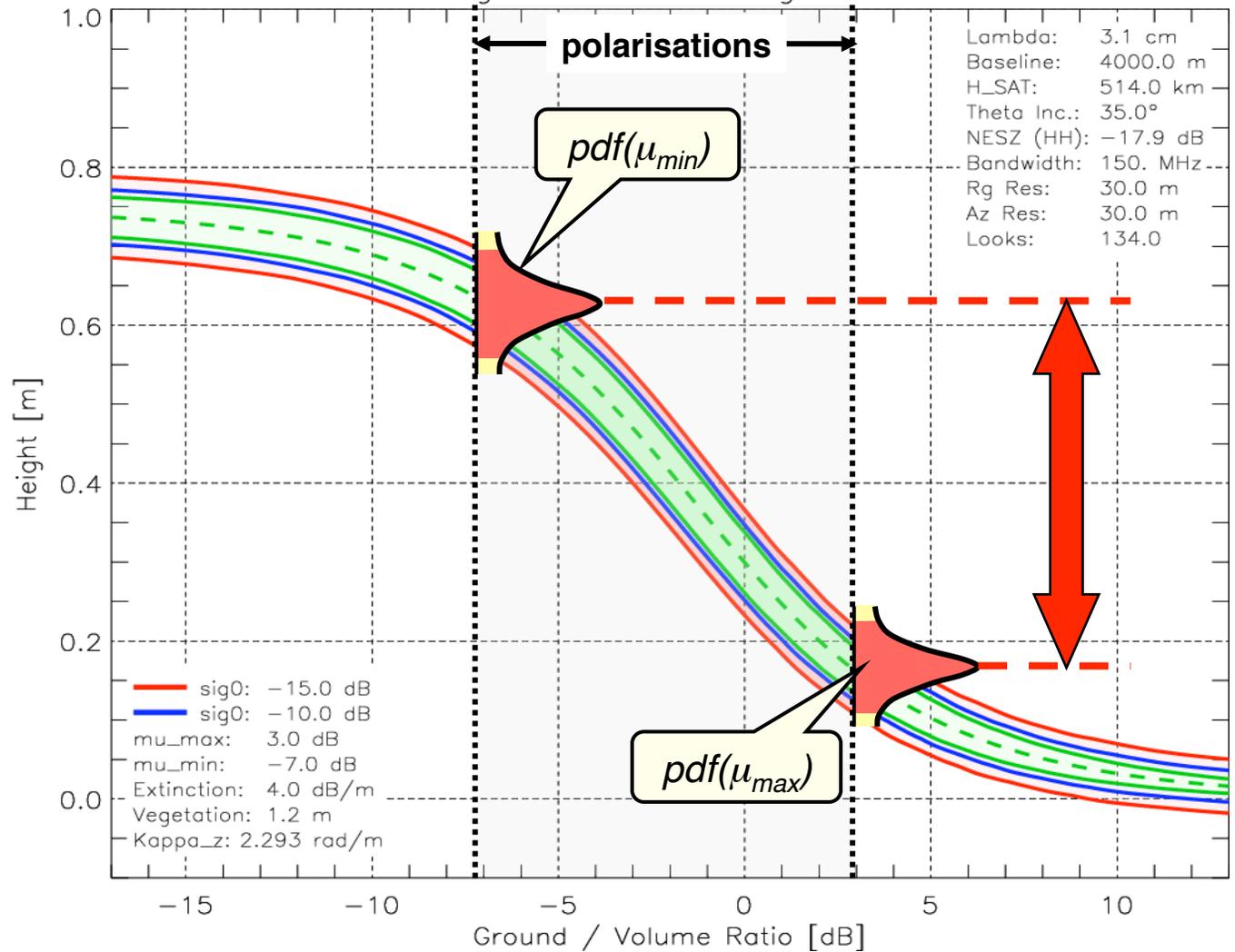
Polarimetric SAR Interferometry



Parameters

- $h = 1.2 \text{ m}$
- $\beta = 4.0 \text{ dB/m}$
- $\mu_{min} = -7.0 \text{ dB}$
- $\mu_{max} = 3.0 \text{ dB}$
- $B_{\perp} = 4 \text{ km}$
- $\theta_{inc} = 35^{\circ}$
- $\Delta x = 30 \text{ m}$

Height Error and Height Bias



TanDEM-X Data Proposal Submission

Deutsches Zentrum für Luft- und Raumfahrt in der Helmholtz-Gemeinschaft

TANDEM DLR

TanDEM-X Science Service System

The TanDEM-X Science Service System allows for the submission and evaluation of proposals, as well as for the submission of reports. It is further used to monitor and track proposals and therewith help to organize the science user community of TanDEM-X.

Depending on who you are and what you like to do you have the following possibilities to proceed via the sidemenu on the left of this page:

- Anybody may receive information about which proposals are accepted and read their executive summaries **proposals (pre-launch)** or **proposals (general)**
- Principal **investigators** of TanDEM-X data may enter and maintain their proposals and are able to submit reports. Proposals and reports should be in English.
- **Evaluators** may receive detailed information about the proposals they have been appointed to and submit their comments and rating.

The pdf document: **How to submit a TDM proposal** gives a short description of the procedure for submitting proposals.

ATTENTION: The download of TanDEM-X data requires special security regulations which are described in the **FAQ** document.

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Summary

- TanDEM-X has outstanding scientific and commercial potentials
- TanDEM-X key technologies are:
 - close formation flying capability
 - bistatic radar operation and phase synchronisation
 - precise baseline determination
 - new algorithms for interferometric processing
- TanDEM-X plays a key role in the development of next generation bistatic and multistatic SAR missions and applications
- Launch in spring 2010